5th Grade

Fall 2019 Lesson Plans

Vanderbilt Student Volunteers for Science

http://studentorg.vanderbilt.edu/vsvs/

VOLUNTEER INFORMATION

Team Member Contact Information

Name:____ Phone Number:________________________

Name:____ Phone Number:________________________

Name:____ Phone Number:________________________

Name:____ Phone Number:________________________

Name:____ Phone Number:________________________

Teacher/School Contact Information

School Name: ____________________________________ Time in Classroom: ____________________

Teacher's Name: ____________________________________ Phone Number: _______________________

VSVS INFORMATION

VSVS Educational Coordinator:

Paige Ellenberger — 615-343-4379

paige.ellenberger@vanderbilt.edu — **VSVS Office:** Stevenson 5234

Co-Presidents:	Eric Zhang	eric.zhang@vanderbilt.edu
	Vineet Desai	vineet.desai@vanderbilt.edu
Secretaries:	Gabriela Gallego	gabriela.l.gallego@vanderbilt.edu
	Emily Chuang	emily.a.chuang@vanderbilt.edu

Vanderbilt Protection of Minors Policy: As required by the Protection of Minors Policy, VSVS will keep track of the attendance – who goes out when and where.
https://www4.vanderbilt.edu/riskmanagement/Policy_FINAL%20-%20risk%20management%20v2.pdf

Before You Go:

- The lessons are online at: http://studentorg.vanderbilt.edu/vsvs/
- Email the teacher prior to the first lesson.
- Set a deadline time for your team. This means if a team member doesn't show up by this time, you will have to leave them behind to get to the school on time.
- Don't drop out from your group. If you have problems, email Paige or one of the co-presidents, and we will work to help you. Don't let down the kids or the group!
- If your group has any problems, let us know ASAP.

Picking up the Kit:

- Kits are picked up and dropped off in the VSVS Lab, Stevenson Center 5234.
- The VSVS Lab is open 8:30am – 4:00pm (earlier if you need dry ice or liquid N_2).
- Assign at least one member of your team to pick up the kit each week.
- Kits should be picked up at least 30 minutes before your classroom time.
- If you are scheduled to teach at 8am, pick up the kit the day before.
- There are two 20 minute parking spots in the loading dock behind Stevenson Center. Please do not use the handicap spaces – you will get a ticket.

While you're there – Just relax and have fun!

September						
SUN	MON	TUES	WED	THU	FRI	SAT
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25 Team Leader Training 6-8 pm	26	27 VSVS Day of Service 3-5pm	28
29 Team Leader Training 6-8pm	30 Team Training 5th &7th Grade (come during your normal lesson time)					

October

SUN	MON	TUES	WED	THU	FRI	SAT
		1 Team Training 5th &7th Grade (come during your normal lesson time)	2 Team Training 5th &7th Grade (come during your normal lesson time)	3 Team Training 5th & 7th Grade (come during your normal lesson time)	4 Team Training 5th &7th Grade (come during your normal lesson time)	5
6	7 Team Training 6th & 8th Grade (come during your normal lesson time)	8 Team Training 6th & 8th Grade (come during your normal lesson time)	9 Team Training 6th & 8th Grade (come during your normal lesson time)	10 Team Training 6th & 8th Grade (come during your normal lesson time)	11 Team Training 6th & 8th Grade (come during your normal lesson time)	12
13	14 Lessons, Week 1	15 Lessons, Week 1	16 Lessons, Week 1	17 Lessons, Week 1	18	19 Mega Microbe 9am-2pm
20	21 Lessons, Week 2	22 Lessons, Week 2	23 Lessons, Week 2	24 Fall Break (lessons scheduled 10/24 will be moved to the week of 11/14)	25 Fall Break	26
27	28 Lessons, Week 3	29 Lessons, Week 3	30 Lessons, Week 3	31 Lessons, Week 3		

November

SUN	MON	TUES	WED	THU	FRI	SAT
					1	2
3	4 Lessons, Week 4	5 Lessons, Week 4	6 Lessons, Week 4	7 Lessons, Week 4	8	9
10	11 Veterans Day, Metro Schools Closed	12 Make ups, Week 1	13 Make ups, Week 1	14 Make ups, Week 1	15	16
17	18 Make ups, Week 2	19 Make ups, Week 2	20 Make ups, Week 2	21 Make ups, Week 2	22	23
24	25	26	27	28	29	30

CLASSROOM ETIQUETTE

Follow Metro Schools' Dress Code!

- No miniskirts, shorts, or tank tops.
- Tuck in shirts if you can.
- Please dress appropriately.

Metro student standard attire guideline:
http://jtmoorems.mnps.org/pages/JohnTrotwoodMooreMiddle/About_Our_School/8998762518461552450/Dress_Code

COLLEGE Q&A SESSION

VSVS members should be candid about their experiences and emphasize the role of hard work and a solid body of coursework in high school as a means to get to college.

- Email the teacher prior to the first lesson.
  - They may want to have the students write down questions prior to your lesson.
  - They may also want to have a role in facilitating the discussion.
- Finish the experiment of the day and open up the floor to the students.
- Remind them of your years and majors and ask if they have specific questions about college life.
- If they are shy, start by explaining things that are different in college.
  - Choosing your own schedule, dorm life, extracurricular activities, etc.
  - Emphasize the hardworking attitude.

The following are some sample questions (posed by students):

- When is bedtime in college? Does your mom still have to wake you up in college?
- How much does college cost?
- What do you eat in college and can you eat in class in college?
- How much homework do you have in college?

DIRECTIONS TO SCHOOLS

H.G. HILL MIDDLE SCHOOL: 150 DAVIDSON RD **615-353-2020**
HG Hill School will be on the right across the railroad lines.

HEAD MAGNET SCHOOL: 1830 JO JOHNSON AVE **615-329-8160**
The parking lot on the left to the Johnston Ave.

J.T. MOORE MIDDLE SCHOOL: 4425 GRANNY WHITE PIKE **615-298-8095**
From Lone Oak, the parking lot is on the right, and the entrance into the school faces Lone Oak, but is closer to Granny White.

MEIGS MIDDLE SCHOOL: 713 RAMSEY STREET **615-271-3222**
Going down Ramsey Street, Meigs is on the left.

ROSE PARK MAGNET SCHOOL: 1025 9th AVE SOUTH **615-291-6405**
The school is located on the left and the parking is opposite the school, or behind it (preferred).

WEST END MIDDLE SCHOOL: 3529 WEST END AVE **615-298-8425**
Parking is beside the soccer field, or anywhere you can find a place. Enter through the side door.

<u>EAST NASHVILLE MAGNET MIDDLE SCHOOL: 2000 GREENWOOD AVE</u> **615-262-6670**

<u>MARGARET ALLEN MIDDLE SCHOOL: 500 SPENCE LN</u> **615- 291- 6385**

From West End down Broadway, take 1-40E to exit 212 Rundle Ave. Left on Elm Hill to Spence Lane.

VANDERBILT STUDENT VOLUNTEERS FOR SCIENCE
http://studentorg.vanderbilt.edu/vsvs

Properties of Iron

Goal: To learn the difference between elements and compounds by studying the different forms of iron. Fits Tennessee standard : 5.PS1.4

VSVSer Lesson Outline:

_________**I. Introduction: Elements, Compounds, and Mixtures**
Discuss elements, compounds, and mixtures and focus on iron.

_________**II What are the Physical Properties of Elemental Iron and Iron Oxide?**................
Students examine the physical properties of iron and iron oxide, including the magnetic properties of elemental iron using a magnet.

_________**III. Chemical Properties of Iron – Rusting**
Students understand the nature of oxidation and how it is a chemical property of elements and compounds.
A. Students observe rusting in a chemical hand-warmer.
B. Students use salt, iron filings and peroxide to observe "speed" rusting.
C. Students recheck the hand-warmer and their experiment.

_________**VI. Review.**

Complete teacher/school information on first page of manual.

1. Make sure the teacher knows the VSVS Director's (Paige Ellenberger) office number and email (in front of manual).
2. Exchange/agree on lesson dates and tell the teacher the lesson order (**any changes from the given schedule need to be given to Paige in writing (email)**).
3. Since this is your first visit to the class, take a few minutes to introduce yourselves. Mention you will be coming three more times to teach them a science lesson.
4. Do the experiment with the classroom, and leave 10 minutes at the end to discuss aspects of college life with them. Some topics that could be included are in the manual.

LOOK AT THE VIDEO BEFORE YOU GO OUT TO YOUR CLASSROOM
https://studentorg.vanderbilt.edu/vsvs/lessons/
USE THE PPT AND VIDEO TO VISUALIZE THE MATERIALS USED IN EACH SECTION.

Materials
1bagcontaining Iron element, compound and mixture models
15 bags containing:
- 1 oz sealed wide-mouth bottle of Iron metal
- 1 oz sealed wide-mouth bottle of iron oxide- Fe_2O_3
- 1 oz sealed wide-mouth bottle of iron filings
- 1 white Teflon magnet

8 HotHands hand warmers
1 ziploc bag containing:
- 1 4 oz bottle with 1 HotHands hand warmer (to be cut open)
- 1 pair of scissors to cut open HotHands hand warmer
- 1 4 oz bottle containing contents of hand warmer exposed to air for 24 hours

15 plates
15 ziploc bags containing 1 oz wide-mouth bottle of iron filings, 1 oz wide-mouth bottle of salt and 1 plastic scoop
1 bag containing 30 1oz cups with cotton balls
1 plastic bin (lined with aluminum foil) containing 15 dropper bottles of water and hydrogen peroxide

1 trash bag
1 binder containing 30 observation sheets, 15 instruction sheets, 16 periodic tables (1 per pair), and 1 ppt

1. In the car ride, read through this quiz together as a team. Make sure each team member has read the lesson and has a fundamental understanding of the material.

Lesson Quiz

1. What is the difference between an element and a compound?
2. What is oxidation and what are some real-world examples of it?
3. Why does hydrogen peroxide cause iron to rust faster?

2. Use these fun facts during the lesson:

- Iron is a mineral that is found in every cell of the body. The most important role of iron in the body is in respiration. Iron binds oxygen in the blood, allowing an adequate supply of oxygen to be carried throughout the body from the lungs.
- Animals and plants require iron. Plants use iron in chlorophyll, the pigment used in photosynthesis. Humans use iron in hemoglobin molecules in blood.
- Iron is the sixth most abundant element in the universe and the fourth most abundant element in the earth's crust. It comprises about 5.6% of the earth's crust and almost all of the earth's core.
- The element symbol for iron is Fe, which comes from the Latin word for iron, "ferrum".
- Steel is made from iron and carbon, which makes it harder than iron. Steel can also be galvanized to prevent iron oxide from forming (i.e. rusting). This process usually involves a very thin layer of zinc being applied to the surface.

Note: The magnets used in this lesson are expensive. Please check carefully to be sure all magnets are returned.

Unpacking the Kit:

VSVSers do this while 1 person is giving the Introduction. Note that students are put into pairs and should have their pencils ready.

For Part I. Elements, Compounds, and Mixtures

16 periodic tables in page protectors (1 per pair)
1 bag containing iron element, compound, and mixture models
15 bags containing 1 oz sealed wide-mouth bottle of Iron metal, 1 oz sealed wide-mouth bottle of iron oxide- Fe_2O_3, 1 oz sealed wide-mouth bottle of iron filings, 1 white Teflon magnet
30 observation sheets and 16 instruction sheets

For Part II - What are the Physical Properties of Elemental Iron and Iron Oxide?

Same as above.

For Part III. Chemical properties of Iron – Oxidation (Rusting)

A. Chemical (HotHands) Hand Warmer

8 HotHands hand warmers
1 ziploc bag containing 1 4 oz bottle with 1 HotHands hand warmer (to be cut open), 1 pair of scissors to cut open HotHands hand warmer, 1 4 oz bottle containing contents of hand warmer exposed to air for 24 hours

B. Oxidation of iron experiment

15 plates
15 ziploc bags containing 1 oz wide-mouth bottle of iron filings, 1 oz wide-mouth bottle of salt and 1 plastic scoop

Your Notes:

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1 bag containing 30 1oz cups with cotton balls
1 plastic bin containing dropper bottles of water and hydrogen peroxide

I. Introduction: Elements and Compounds.

Learning Goals: To help students identify the key factors that differentiates elements and compounds.

Why is the science in this lesson important?

Our body needs certain vitamins and minerals to survive, and iron is an important mineral required for adequate delivery of oxygen to different tissues. However, iron deficiency is also the most common and widespread nutritional deficiency in the world. Giving newborns with low birth weights iron supplements helps prevent behavioral and neurological problems later in life. The importance of iron in diet is still being researched, and new functions of iron are still being discovered!

Materials

16 periodic tables in page protectors (1 per pair) – in binder
Iron element, compound, and mixture models

Write the following on the board:

element, compound, mixture, **elemental iron**, **Fe, Fe_2O_3**

Hand out the large periodic tables in page protectors.
Ask students: What is the difference between an element and compound? (Keep the discussion as simple as possible.)

- **Elements** are the building blocks of matter. Use the periodic table while you discuss elements.
  - Show students the element models. Explain that there is only one kind of atom here.
    - One bag contains only red balls. The **red** balls represent **iron**.
    - The other bag contains only **blue** balls which represent **oxygen**.
  - Show students the placement of iron and oxygen in the periodic table.

- **Compounds** are made up of two or more **elements that are chemically bonded together.**
  - Show students the rust (iron oxide) model. Explain that there are two kinds of atoms here and that they are connected to one another.
    - The red atom is iron and the blue atom is oxygen.
    - Tell students that there are two iron atoms for every three oxygen atoms.
    - Other examples of compounds include water (H_2O), carbon dioxide (CO_2), table sugar ($C_{12}H_{22}O_{11}$), and table salt (NaCl).

Tell the students that in today's lesson you will be studying some physical and chemical properties of elemental iron**.**

Give each pair a bag containing:

1 oz sealed wide-mouth bottle of Iron metal
1 oz sealed wide-mouth bottle of iron oxide- Fe_2O_3
1 oz sealed wide-mouth bottle of iron filings

Your Notes:

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1 white Teflon magnet

Give each student an observation sheet and an instruction sheet.

Tell the students to look at the labels on the bottles.

Ask students:

- How can we tell if a chemical is an **element or a compound**? *The formula for an element contains only one atomic symbol, whereas the formula for a compound contains more than one atomic symbol.*
- Which containers have the element? *Fe (Iron Filings and iron metal)*
- Which container has the compound? *Fe_2O_3 (rust)*
  - Point out to students that iron oxide is a compound because it has two different elements - iron, and oxygen - which are chemically combined. The small numbers give the ratio of elements in the compound.
  - Ask students what happens when an iron shovel is left outside? *When it is left outside, the iron reacts with oxygen to form rust, which is iron oxide.*

Tell the students:

- Every compound has its own properties, which are different from the properties of the elements that make up the compound. In their tests today, the students will study the physical and chemical properties of elemental iron and iron in iron oxide (rust).

II. What are the Physical Properties of Elemental Iron and Iron Oxide?

Learning Goals: To help students characterizes elements and compounds based on physical properties.

A. **Physical Properties of Elemental Iron and Iron Oxide.**
   a. **Ask students: What are some <u>physical properties</u> of elemental iron?** *Iron is a metal. It is hard. It is shiny. It is attracted to magnets*
   b. **Ask students: What are some physical properties of the compound iron oxide?** *Iron oxide is a powder. It is red. It is not attracted to a magnet.*

- Tell the students to put the magnet on the **outside** of the iron metal and the iron filings container, and to slowly move it up the side or across the vial. What happens?
- Have them repeat this with the iron oxide.
- Emphasize that the physical properties of elemental iron and iron compounds are not the same.
- Have students check the appropriate blank for Part II on the observation sheet.

III. Chemical Properties of Iron – Oxidation (Rusting)

Learning Goals: To assist students in understanding the nature of oxidation, and how it is a chemical property of elements and compounds

Ask students if they know what **oxidation** means? *Oxidation usually occurs when an element or compound combines with **oxygen**.*

What are some things that **oxidize**?

Cut fruits oxidize – apples turn brown after they have been cut and left exposed to air.
Copper oxidizes and becomes a dull color (new pennies are shiny; older ones are dull).
Silver becomes "tarnished" and black when it oxidizes.
Iron is oxidizing when it rusts and turns a reddish color.

This is a chemical property of iron.

Your Notes:

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Rust is the common name for a very common compound, iron oxide. Rusting is a very slow process which takes place over several weeks or months.
Ask students to name things that rust? *Anything made of iron, that is left outside (in the rain) will rust faster than things kept dry and inside. Examples may include gardening tools, bicycles, anything with exposed iron.*

A. Commercial HotHands Pack.
Show the students one of the commercial HotHands. Ask the students if anyone has used one? Campers or hunters use these to keep their hands warm in cold weather.

Give each group of 3-4 students a HotHands pack and tell them to remove the plastic covering and touch the pack so that they can feel that it is at room temperature.
Tell one member in the group to shake it to activate it and then set it aside until after the next experiment has been set up.
Note: The directions on the plastic covering suggest waiting 30 minutes, but students will be able to feel warmth from the hand warmer after about ten minutes.

How do HotHands work?

- Have students look at their observation sheet to read the list of ingredients in the HotHands warmer.
- Tell the class that the "missing ingredient" that is needed to make the hand warmer warm up is **oxygen.** When the plastic covering is removed, the inside pouch is porous enough to allow air to enter the pouch. The oxygen in air reacts with iron to form iron oxide with the release of heat.
- This is same reaction as rusting (iron + oxygen + water). The iron + oxygen + water reaction in the HotHands pack is 1000 times faster than normal rusting.

Have students go on to Part B while they are waiting for the hand-warmers to get warm.
Ask students if they have ever seen iron rust in a few seconds? *Probably not!*
Tell the students they are going to put some chemicals together that will cause rusting in just a few minutes.

B. Experiment - Rusting of Iron Filings

Give each student goggles.
Hand out the following materials to each pair,

1 plate
1 ziploc bag containing:
1 1 oz wide-mouth bottle of iron filings
1 1 oz wide-mouth bottle of salt
1 plastic scoop
2 1oz cups with cotton balls
1 dropper bottle containing water
1 dropper bottle containing hydrogen peroxide

Tell students to:

1. Note – the reason for using the cotton is to make the color change due to rusting more obvious.
2. Sprinkle iron filings on top of the cotton in each cup (a small scattering is all that is needed).

Each piece of cotton will now be treated differently.

Your Notes:

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Tell students to

3. Add a **squirt of water** on top of the filings in the 1st cup.
4. Add a sprinkle of salt and a **squirt of hydrogen peroxide** on top of filings in the 2nd cup.

Have the students observe the 2 cups for a few minutes and then ask them what differences they can see. Have students answer the questions in Part III of the observation sheet. Answers may include:

The cotton containing iron and water (cup 1) does not have orange coloring.

The cotton containing the hydrogen peroxide and salt (cup 2) will have some orange color (rust).

Set aside to observe again later.

Explanation

For iron to rust & become iron oxide, 3 things are required: **iron, water and oxygen.**

The equation for oxidation of iron is: $4Fe + 3O_2 \text{ -----› } 2Fe_2O_3$

Hydrogen peroxide is a good source of oxygen.

Iron can rust without salt being present, but it will make rusting even faster (it is a catalyst). Iron objects close to the ocean rust faster. Cars rust faster when we salt the roads in the winter to melt ice.

Write the formulas for hydrogen peroxide and water on the board: H_2O and H_2O_2 to show the students that there is more oxygen ("O") in the peroxide.

Ask students which of the 2 cups had the best conditions for rusting? *Cup 2, because the hydrogen peroxide could supply more oxygen than just water (as in cup 1), and salt speeds up rusting.*

C. Checking the HotHands Hand Warmer

- Have the students feel the hand warmer. (It should feel warm.)
- The oxygen in air reacted with iron to form iron oxide with the **release of heat**.
- Tell students this is an example of an exothermic process. *Exothermic, heat is released*
  Take the empty 4 oz jar, cut open a hand warmer pouch and pour the contents inside the jar. Show the students this jar and compare what the contents look like with the jar that contains contents of a HotHands hand warmer that were exposed to air for 24 hours.
- *(In the 24-hour jar, the black color of iron powder has changed to a brownish, somewhat clumpy solid, which is iron oxide. The change in color and characteristics of the solid are evidence for a chemical change.)*

For VSVS information only:

Why did the temperature change? *The chemical reaction producing the iron oxide is an exothermic reaction, which means that it gives off energy in the form of heat.*

In everyday life, why don't objects that rust get hot? *Iron filings have a large surface area in contact with the water or salt, so the rusting occurs very rapidly. Most rusting objects in everyday life, such as cars, shovels, etc., have a smaller surface area that is rusting and thus will not rust nearly as fast and therefore will not generate the heat observed in your experiment.*

How does rusting generate heat? *Changes in the energy held by chemical bonds in the oxidation of iron yield a net loss of energy from the reactants, and this net loss escapes to the surroundings where it is felt as heat.*

Your Notes:

IV. Review and Clean-up.

Review the vocabulary words and the responses to the questions on the Observation Sheet.
Students can check the cups with iron filings to observe the reactions again.

Return all cups with used iron filings in the plastic trash bag.
The HotHands hand-warmer can be left in the classroom with the teacher or the students, returned to the VSVS lab or kept by the VSVS members.

Lesson written by: Dr. Melvin Joesten, Emeritus Professor, Vanderbilt University
Pat Tellinghuisen, Program Coordinator of VSVS 1998-2018, Vanderbilt University
Heather Day, Program Assistant for VSVS, Vanderbilt University

Your Notes:

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Properties of Iron
Observation sheet

NAME ____

VOCABULARY WORDS:
element, compound, mixture, elemental iron, Fe, Fe_2O_3

I. Elements, Compounds, and Mixtures
Which containers have the element iron? *Fe (Iron Filings and iron metal)*
Which container has the compound? *Fe_2O_3 (rust)*

II Test for Elemental Iron Using a Magnet – a physical property
Circle the correct answer.
Are the **<u>elemental</u>** iron filings and iron metal magnetic? Yes No

Is the **<u>compound</u>** iron oxide magnetic? Yes No

Is magnetism a physical or chemical property? Physical Chemical

IIIA. Commercial HotHands Pack.

HotHands ingredients: Iron Powder, Water, Salt, Activated Charcoal, Vermiculite

For iron to rust & become iron oxide, 3 things are required: **iron, water and oxygen.**
The equation for oxidation of iron is: $4Fe + 3O_2$ -----› $2Fe_2O_3$

What element is missing in order for the iron to oxidize? _______________
IIIB. Rusting – a chemical property of Iron

In cup 1, water H_2O) is added to the iron filings. What happens?

____

In cup 2, hydrogen peroxide (H_2O_2) and salt are added to the iron filings. What happens?

____

Which cup had more oxygen available?

What happened to the HotHands Pack after it was activated? ________________________________

Properties of Iron
ANSWER OBSERVATION SHEET

NAME ____

VOCABULARY WORDS:
element, compound, mixture, elemental iron, Fe, Fe_2O_3

I. Elements, Compounds, and Mixtures

Which containers have the element iron?

Fe Iron Filings and Fe Iron Metal)

Which container has the iron compound?

Fe_2O_3 (rust)

II. Test for Elemental Iron Using a Magnet – a physical property

Are the **elemental** iron filings and iron metal magnetic? _X_ Yes ____ No

Is the **compound** iron oxide magnetic? ____ Yes _X_ No

Is the property of magnetism a physical or chemical property (circle the answer)?

physical ~~chemical~~

IV. Rusting – a chemical property of Iron

What happened in cup 1? *Nothing*

What happened in cup 2? *The iron filings turned orange. They rusted.*

What happened to the Hothands Pack after it was activated? *It became warmer.*

VANDERBILT STUDENT VOLUNTEERS FOR SCIENCE

Cryogenic Temperatures

Goal: To investigate the properties of substances at extremely cold temperatures (referred to as cryogenic temperatures). To illustrate that changes in phases of matter are physical changes.

TN Curriculum Alignment: 5PS1.1, 5PS1.2

VSVSer Lesson Outline

_______ **I. Introduction**
Discuss the meaning of the word *cryogenic*s and the properties of nitrogen. Also discuss physical and chemical changes.
Discussion of the Cold Temperature of Boiling Nitrogen
Give each pair of students one of the diagrams (in binder) of a thermometer and use this to help students understand how cold liquid nitrogen is by comparing the markings for the boiling point of water, freezing point of water, the sublimation temperature of dry ice, and the boiling point of liquid nitrogen.

_______ **II. Demonstration of Liquid Nitrogen**
Put on gloves and goggles. Pour some liquid nitrogen into a clear 10 oz cup. Use a glove to hold the cup high enough for students to see. Ask them to write down their observations on the observation sheet. Draw a picture of the cup on the board and discuss the students' observations.

_______ **III. Demonstration - Hammering a Nail with a Banana**
<u>Note: Never place any objects in the liquid nitrogen dewar since it is going to be used to make ice cream. There is a small dewar (one made from two clear plastic bottles with packing peanuts for insulation.</u>) Pour liquid nitrogen from the large dewar into the smaller insulated container. Even if you are wearing gloves, the temperature is too cold for these to protect you. Attempt to hammer a nail into a piece of wood with a banana. Then cool the bottom half of the banana in the small dewar that has been filled with liquid nitrogen. After the banana has been in the liquid nitrogen for several minutes, use the banana to pound a nail into the piece of wood.

_______ **IV. Demonstration - Rubber Tubing in Liquid Nitrogen**
Demonstrate the loss of elasticity of rubber by bending the middle of two pieces of split rubber tubing and putting the bent middle portion in the small dewar used for the banana. After removing the pieces of rubber tubing from liquid nitrogen, take one piece and quickly and forcefully hit the cold end against the top of the table. This should shatter the tubing. Allow the other piece of rubber tubing to warm up to show the flexibility of the rubber returns.

_______ **V. Demonstration - Shrinking a Balloon and Whistling Tea Kettle**
Blow up a balloon, place it in the bowl, and pour liquid nitrogen over it. <u>Do not use an excessive amount of liquid nitrogen in order to have about one-third of the liquid nitrogen left for making ice cream.</u>
Put a small amount of liquid nitrogen into a tea kettle and explain the whistling.

_______**VI. Demonstration - Making Ice Cream**

_______**VII. Review**

LOOK AT THE VIDEO BEFORE YOU GO OUT TO YOUR CLASSROOM
https://studentorg.vanderbilt.edu/vsvs/lessons/
USE THE PPT AND VIDEO TO VISUALIZE THE MATERIALS USED IN EACH SECTION.

1. Before the lesson:
In the car ride, read through this quiz together as a team. Make sure each team member has read the lesson and has a fundamental understanding of the material.

1. What is Cryogenics?
2. What happens to liquid nitrogen when placed in a cup?
3. What is a physical change?
4. What is a chemical change?

2. During the Lesson:
Here are some Fun Facts
Liquid Nitrogen:

- Liquid nitrogen boils at 77 K (−195.8°C or −320.4°F).
- Nitrogen is non-toxic, odorless, and colorless.
- It can be used for freezing and transporting food products.
- Used for preservation of biological samples
- Gaseous nitrogen makes up about 78% of air.
- Your body is about 3% nitrogen by weight.
- Liquid nitrogen is used in medicine. (Dermatologists use liquid nitrogen to remove warts and moles.)

Unpacking the Kit– What you will need for each section:

For Part I – Introduction:
17 Thermometer diagrams in sheet protectors (one for VSVS team)

For Part II. Demonstration #1: Liquid Nitrogen
1 10 oz. clear plastic cup, 1 large dewar of liquid nitrogen, 1 pair of gloves
32 Observation Sheets

For Part III. Demonstration #2: Hammering with a Banana
1 piece of wood, 1 nail, 1 banana, liquid nitrogen, 1 small dewar (small plastic insulated bottle, 1 pair of gloves

For Part IV. Demonstration #3: Rubber Tubing in Liquid Nitrogen
2 pieces bicycle inner-tube, 1 pair of gloves, 1 pair of tongs, 1 pair of safety goggles for VSVS team member doing rubber tubing demonstration
From Part III: 1 small dewar (made from plastic bottles) of liquid nitrogen

For Part V. Demonstration #4: Whistling Tea Kettle and Shrinking a Balloon
1 inflated balloon (tied off), 1 large stainless steel bowl, 1 whistling tea kettle, 1 ladle
From Part IV: 1 dewar of liquid nitrogen, 1 pair of gloves (Put On!)

For Part VI. Demonstration: Making Ice Cream with Liquid Nitrogen
1 stirring spoon or spatula, 1 quart of whole milk, 1 box of ice cream mix
32 small paper cups for ice cream, 32 taster spoons for ice cream

Your Notes:

2 pairs of gloves
1 large dewar of liquid nitrogen (from Part V1), 1 large stainless steel bowl

For Part VII. Review

1 newspaper article on cryogenics - "Company puts freeze on metals to extend use"

Safety Precautions: Team members pouring liquid nitrogen and doing experiments with liquid nitrogen need to wear **safety goggles**. Always pour **from the large nitrogen dewar to small containers**. **Never** try to fill a small container by dipping it in the large dewar. You risk frostbite if your skin is exposed to liquid nitrogen. **The cotton gloves are provided only for use when pouring and will not provide protection.**

I. Introduction

One VSVS team member should write the following vocabulary words on the board while another member leads the introduction:

Cryogenics, chemical change, dry ice, condensation, physical change, liquid nitrogen

Learning Goals:

- Students understand that different materials have different freezing and melting points.
- Students identify physical and chemical changes, and make observations about how they change the properties of matter.

Ask students if they have ever heard of **cryogenics.**

- If they have, ask them to share what they know.
- *If they haven't, share some of the following information with them:*
  - **Cryogenics** is a branch of physics that deals with the production and effects of very low temperatures.
  - Substances such as liquid nitrogen that are used for cooling things to very low temperatures are called **cryogens**.
  - The derivation of the word cryogen is from the Greek "kryos", meaning "icy cold".
  - Cryogens represent special hazards since contact with cryogens produces instantaneous frostbite, and structural materials such as plastics, rubber gaskets, and some metals become brittle and fracture easily at these low temperatures.
  - Cryogenics is used by companies to make some metal tools more durable and less likely to break under stress.

Ask students: What do you know about **nitrogen**?
Include the following points in the discussion:

- **Nitrogen** is a gas that makes up **78% of the air**. Oxygen makes up 21%, and the rest is made up of other gases such as argon, carbon dioxide, water vapor, and trace amounts of neon and krypton.
- Nitrogen liquefies at -196° C or -320° F.
- Liquid nitrogen is used in medicine. (Dermatologists use liquid nitrogen to remove warts and moles.)
- Since nitrogen is not reactive, liquid nitrogen has found wide use in frozen food preparation and preservation during transit to grocery stores.

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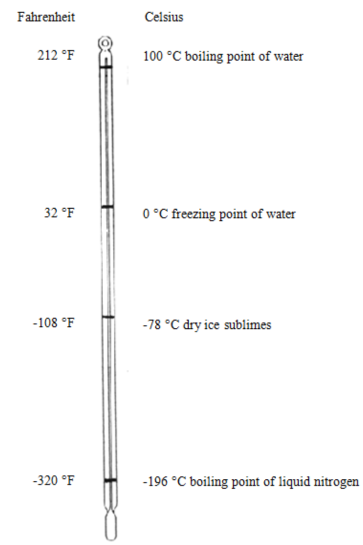
Ask students: What are some examples of physical and chemical changes?
Include the following points in the discussion:

- **Physical changes** involve changes in the phase of a substance. Examples: Liquid water freezes to form ice or boils to change to water vapor gas. All three forms are chemically the same and have the same formula. H_2O.
- **Chemical changes** involve the reaction of two substances to create a new substance with a different formula and may be evidenced by a color change, the formation of a gas or precipitate.

DISCUSSION OF THE COLD TEMPERATURE OF BOILING NITROGEN

Give each pair of students one of the thermometer diagrams and use this diagram to help students understand how cold liquid nitrogen is by comparing the markings for the boiling point of water, freezing point of water, the sublimation temperature of dry ice, and the boiling point of liquid nitrogen.



II. Demonstration #1: Liquid Nitrogen

Learning Goals: Students identify physical and chemical changes, and make observations about how they change the properties of matter

Materials:

1 10 oz. clear plastic cup
1 large dewar of liquid nitrogen
1 pair of gloves
32 Observation Sheets

- Give each student one of the observation sheets.
- Pour liquid nitrogen into the 10 oz. clear plastic cup so that it is half full.
- Use a glove to hold the cup up high enough so students can see the liquid nitrogen. Then set the cup on the front desk (well away from any students to avoid skin contact).
- Have the students look at the liquid nitrogen, but **do not** allow them to touch it. Liquid nitrogen is not toxic, but the temperature is so cold that it will hurt the skin.
- Ask the students to draw a cup on their observation sheet and write down what they see happening in and around it.
- Draw a picture of the cup on the board and ask the students to tell you what happened. Write these observations around the drawing. Students may not have observed all of the following. If

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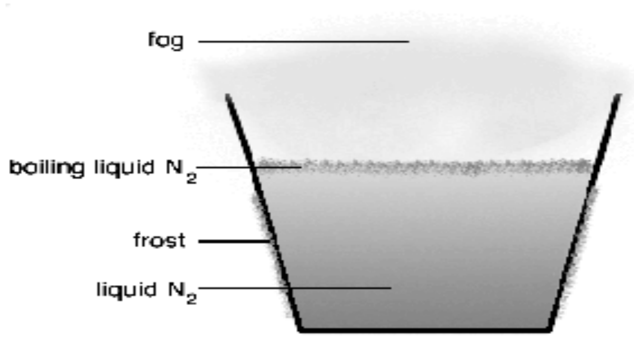
not, point them out.
1. Liquid nitrogen boils.
2. Fog is formed which goes down when it gets to the air outside the cup.
3. Frost is formed on the side of the cup



Ask students: What is happening to liquid nitrogen and is this a physical or chemical change*?*

Include the following points in the discussion:

1. Liquid nitrogen boils (changes from a liquid to a gas) because the temperature of the room (about 25 °C) is much higher than the boiling point of liquid nitrogen (–196°C). ***This is a physical change.***

2. Fog forms above the liquid nitrogen. ***This is a physical change***.
   - The fog is not liquid nitrogen but solid water (ice particles) suspended in the cold nitrogen gas above the liquid nitrogen.
   - Gaseous nitrogen is colorless as evidenced by the fact that we can't see air, which is 78% nitrogen.
   - The fog goes down after it leaves the cup because the cold nitrogen gas contains crystals of water, which makes the fog heavier than air. Remind students that this is why regular fog is close to the ground – fog contains air mixed with small drops of water.

3. Condensation on the outside of the plastic cup is water vapor (gas) from the air, changing to liquid water.
   - The water droplets are quickly frozen by the low temperature of the liquid nitrogen to form solid water (frost or ice). ***These changes are also physical changes***.
   - Most students will report only seeing the frost since the water droplets are only observable for a brief time before they turn to solid water (frost).

Note: Tell students that the next few experiments will show some of the things that can be done with liquid nitrogen. **Ask them to decide whether each experiment involves a chemical or physical change and to underline their choice on their Observation Sheet.**

III. Demonstration #2: Hammering with a Banana

Learning Goals:
- **Students identify physical and chemical changes, and make observations about how they change the properties of matter.**
- **Students observe, describe, and explain physical changes that occur at cryogenic temperatures**

Materials
1 piece of wood
1 nail
1 banana
1 large dewar of liquid nitrogen
2 small dewar - small plastic insulated bottle
1 pair of gloves

Note: **Do not** place any objects in the large liquid nitrogen dewar since it is going to be used to make ice cream. There is a small dewar (one made from two clear plastic bottles with packing peanuts for insulation) for freezing the banana and rubber tubing.

- Show students the nail and piece of wood.
- Tell them that you forgot your hammer so you think you'll just use the banana.
- Ask students if they think you can hammer the nail into the piece of wood with the banana.
- Attempt to hammer the nail into the board with the banana. **Watch out! This can be messy.**
- Tell the students that you think the banana needs a little help.
- Fill the small dewar about two-thirds full with liquid nitrogen.
- Put the banana in the small dewar.
- Wait 2-3 minutes for the liquid nitrogen to cool the banana. Ask the next two questions while you wait.
    - Ask students to predict what the banana will look like when it comes out of the liquid nitrogen. Ask the students if they think you will be able to hammer a nail into the board this time.
- When 2-3 minutes have passed, use a glove to pull the banana out of the liquid nitrogen and hammer the nail into the board.

Note: Please dispose of banana at the school, before the box is returned to the VSVS lab.

IV. Demonstration #3: Rubber Tubing in Liquid Nitrogen

Learning Goals:
- **Students identify physical and chemical changes, and make observations about how they change the properties of matter.**
- **Students observe, describe, and explain physical changes that occur at cryogenic temperatures**

Materials:
2 pieces of rubber tubing or bicycle inner-tube (tubing **must be** slit down the middle to avoid the possibility of liquid oxygen collecting)
1 small dewar (made from plastic bottles) of liquid nitrogen
1 pair of gloves
1 pair of tongs

<u>Important Safety Note: The VSVS team member performing this demonstration must wear safety goggles.</u>

- Use the small dewar of liquid nitrogen from Demonstration #2.

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- Hold up a piece of split rubber tubing and demonstrate how flexible it is by bending it back and forth.
- Take the two pieces of split rubber tubing and bend in half at the middle (not kinked but a little rounded) and while holding the pieces of tubing together at the open ends, immerse the bent middle portions into the small dewar containing the liquid nitrogen for about one minute.
- While the middle of the rubber tubing is in the liquid nitrogen, ask students what they think the cooling in liquid nitrogen will do to the rubber tubing. *Accept logical responses.*
- Take the pieces of rubber tubing out of the liquid nitrogen, and put one piece aside to warm up to room temperature. **Caution: Have safety goggles on for this part**. Take the other piece and quickly and forcefully hit the cold end against the top of the table. This should shatter the tubing.

Explanation: Rubber is made up of long chains of molecules that are loosely coiled. The elasticity of rubber is caused by coiling and uncoiling of these long chains. At liquid nitrogen temperatures the molecular motion is slowed down enough that the coils are locked into one position.

- Pick up the rubber tubing that was allowed to warm to room temperature and show the students that it is flexible again.

Explanation: When the temperature of the rubber becomes warmer, the elasticity of the rubber returns because the molecular motion increases again and allows the coiling and uncoiling of the polymer chains.

- Ask the students: Are the changes in elasticity with temperature a physical or chemical change? ***Physical because the rubber recovers its elasticity when it warms up*.**

V. Demonstration #4: Whistling Tea Kettle and Shrinking a Balloon

Learning Goals:

- **Students identify physical and chemical changes, and make observations about how they change the properties of matter.**
- **Students observe, describe, and explain physical changes that occur at cryogenic temperatures**

Materials:

1 inflated balloon (tied off)
1 dewar of liquid nitrogen
1 large stainless steel bowl
1 pair of gloves (Put On!)
1 whistling tea kettle
1 ladle

A. Whistling Tea Kettle

Ask the students if they know what happens when water is boiled in a whistling tea kettle. *The whistle makes a loud whistling noise when water boils.*

Ask – what causes the whistle? *The boiling water (liquid) creates steam (a gas).*

Pressure builds up and the steam has nowhere to go, except through a hole in the lid. **(Show the students the hole.)**

When enough steam has been created so that it rushes through the hole, vibrations are set up, causing the kettle to whistle.

Use the ladle to put some liquid nitrogen into the kettle. Ask the students to explain why the kettle is whistling.

*The **liquid** nitrogen is boiling, producing nitrogen **gas,** which is forced out through the hole, setting up vibrations, in the same way the steam from the boiling water was.*

Your Notes:

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B. Shrinking a Balloon

- Show an inflated balloon to the class.
- Ask students to predict what will happen to the balloon when you pour liquid nitrogen over it. Accept logical responses.
- Put the bowl in a spot where students can see it.
- Place the inflated balloon in the bowl.
- Tell students to watch and to be very quiet so they can hear what happens.
- Pour a small amount of liquid nitrogen over the balloon.
- The balloon will shrink and crackle as it gets cold.
- Ask students to predict what will happen when you pull the balloon out of the bowl. Accept logical responses.
- Use a glove and remove the deflated balloon from the bowl.
- As you hold the balloon in the air, the students will be able to observe the balloon inflate and return to its original state.

Explanation

Gases contract when cooled and expand when heated. The volume of a gas is directly related to the temperature. Therefore, the balloon was larger in the warmer air of the room and smaller in the coldness of the liquid nitrogen. This can be explained by the molecular motion of the gas molecules. They move faster at higher temperatures and as a result, take up more room (volume). When the molecules of gas are cooled, they slow down and take up less room (volume).
Ask students: Are these chemical or physical changes? ***Physical***

VI. Demonstration: Making Ice Cream with Liquid Nitrogen

Materials:
1 stirring spoon or spatula
1 quart of whole milk
1 box of ice cream mix
1 large dewar of liquid nitrogen
1 large stainless steel bowl
32 small paper cups for ice cream
32 taster spoons for ice cream
2 pairs of gloves (have handy in case they are needed)

- Make sure you have goggles and gloves on.
- Tell students that liquid nitrogen is great for making a quick batch of ice cream.
- Pour all (1 quart) of the whole milk into the bowl.
- Open the ice cream mix and sprinkle it on top of the milk. Stir to mix.
- Have one VSVS volunteer **slowly** pour about 1 pint of liquid nitrogen into the bowl while another volunteer holds the bowl still and stirs the mixture.
- **Slowly** add more liquid nitrogen.
- **Stop** if any of the liquid turns solid. If ice cream becomes too hard, wait a few minutes for it to soften.
- Put a small amount in enough cups to serve everyone. Pass these out with the taster spoons.

Your Notes:

Note: The slower the liquid nitrogen is added, the better the consistency of the ice cream. Pour the liquid nitrogen at about the rate of a drip coffee machine for about 20 to 30 seconds. Then stop and look. Continue pouring the liquid nitrogen at a slow rate. Have the stirrer check every 20-30 seconds for the consistency of soft serve ice cream.

Clean-Up: Throw away the banana and the milk carton. Empty the water/dry ice bottle – make sure there is no cap on it. Discard pieces of broken balloon and small pieces of rubber tubing. Put the bowl and spoon back in the trash bag and place it in the kit. Be sure to return both the liquid nitrogen dewar and the kit to the VSVS lab.

Note: If there is any liquid nitrogen left at the END of the lesson you can pour some on the floor to allow students to watch it roll around.

BE SURE TO ASK THE TEACHER BEFORE YOU DO THIS!

VIII. Review

Chemical and Physical Changes:

- Review the physical and chemical change responses on the students' observation sheets. See answer sheet.

Cryogenics

- **Cryogenics** is a branch of physics that deals with the production and effects of very low temperatures.
- Substances such as liquid nitrogen that are used for cooling things to very low temperatures are called **cryogens**.
- The derivation of the word cryogen is from the Greek "kryos", meaning "icy cold".
- Containers used to hold cryogens are large vacuum-walled bottles much like the thermos used to carry hot soup or coffee.

Liquid Nitrogen:

- Nitrogen is a gas that makes up 78% of the air. (Oxygen makes up 21%, argon 0.9%, and the rest is made up of other gases such as carbon dioxide, water vapor, and trace amounts of neon and krypton.)
- Nitrogen liquefies at -196° C or -320° F.
- Liquid nitrogen is used in medicine. (Dermatologists use liquid nitrogen to cool a localized area of skin prior to removal of a wart or mole.)
- Since nitrogen is not reactive, liquid nitrogen has found wide use in frozen food preparation and preservation during transit to grocery stores.

Hazards Associated with Cryogenics:

Cryogens represent special hazards since contact produces instantaneous frostbite, and structural materials such as plastics, rubber gaskets, and some metals become brittle and fracture easily at these low temperatures.

Share this information about the Challenger Explosion

The tragic explosion of the space shuttle Challenger in January, 1986 was caused by the effect of cold temperatures on a rubber gasket. The rubber gasket was used to seal joints in the booster rockets to prevent contact with the hydrogen fuel tanks. The cold launch temperature on that

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January day made the rubber gasket lose some of its elasticity. This allowed flames from the booster rocket to burn through the hydrogen fuel tank and cause the explosion that killed the astronauts and the teacher-in-space, Christa McAuliffe.

Share this information about the news article "Company puts freeze on metals to extend use" (in binder).

Read the article before going to the class so you can share the information with students.
Highlights from the article are listed below:

- Cryo-Processing of Tennessee freezes metal items - drill bits, saw chains, punch tools, musical instruments, guitar strings - at temperatures hundreds of degrees below zero, and then quickly reheats them, to strengthen their molecular structure.
- This process makes these items more durable and less likely to break under stress.
- This means less cost for the company or individual forced to spend precious time replacing or repairing the items. A company has increased production due to decreased downtime to replace the tools.
- The company in the article cryo-processes twice a week for 48 hours each time. They also do some quick heat processing - called "sweetening" - before they put it in the "fridge".
- This technique was developed by a Decatur, Illinois firm called 300 Below. It uses a chest-freezer-sized piece of equipment to hold parts while liquid nitrogen gradually cools the air surrounding them.
- Cryo-Processing can treat golf clubs and golf balls to give an increased driving distance. Tennis rackets and aluminum baseball or softball bats can be treated cryogenically.
- The cost of cryo-processing varies according to volume. One to five pounds cost $49.50 per pound. 10 pounds drops to $9.75 per pound. A ton of cryo-processed equipment will cost $2.54 a pound.

Old tires can be frozen in liquid nitrogen to make them so brittle that they can be ground to a fine powder and then used in paints, coatings and sealants. These products then take on some of the qualities of rubber – they are more elastic and impact resistant. (Time, March 3 2008).

If time permits, use the insert in the article ("Just pop it in the fridge") and draw the molecules on the board. Share the explanation in the article with the students to show what happens to the molecules before, during, and after cryogenic treatment.

Lesson written by Dr. Melvin Joesten, Chemistry Department, Vanderbilt University
Pat Tellinghuisen, Director of VSVS, Vanderbilt University
Dr. Todd Gary, former Coordinator of VSVS, Vanderbilt University
Susan Clendenon, Teacher Consultant, Vanderbilt University

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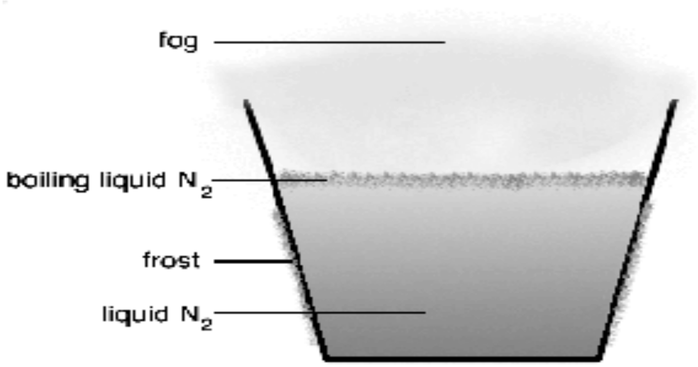
ANSWER SHEET

OBSERVATION SHEET – Cryogenics

Name ____

Demonstration #1 – Liquid Nitrogen – The VSVS team adds liquid nitrogen to a clear cup.

Draw a cup like the one being used and write down everything you see happening in and around the cup. (List of possible observations and labeled cup given on page 5 of lesson.)



Are the following physical or chemical changes? Circle your response.

Boiling liquid nitrogen:	Chemical	<u>Physical</u>
Formation of fog:	Chemical	<u>Physical</u>
Condensation:	Chemical	<u>Physical</u>
Freezing and thawing of banana:	<u>Chemical</u> or	<u>Physical</u>

(You may get both responses here. Since the banana skin turns brown, this would indicate a chemical change. However, the banana still tastes like a banana, although the part that was frozen is mushy.)

Cooling and warming rubber tubing	Chemical	<u>Physical</u>
Shrinking and inflating balloon:	Chemical	<u>Physical</u>
Making ice cream:	Chemical	<u>Physical</u>

(The ice cream mix contains flavor and sugar; mixing and freezing this with milk is a physical change.)

OBSERVATION SHEET - Cryogenics

Name ____

<u>Vocabulary words:</u> **cryogenics**
dry ice
physical change
chemical change
condensation
liquid nitrogen

Demonstration #1 – Liquid Nitrogen – The VSVS team adds liquid nitrogen to a clear cup. Draw a cup like the one being used and write down everything you see happening in and around the cup.

Are the following physical or chemical changes? Underline your response.

Boiling liquid nitrogen:	Chemical	Physical
Formation of fog:	Chemical	Physical
Condensation:	Chemical	Physical
Freezing and thawing of banana:	Chemical	Physical
Cooling and warming of rubber tubing	Chemical	Physical
Shrinking and inflating balloon:	Chemical	Physical
Making ice cream:	Chemical	Physical

VANDERBILT STUDENT VOLUNTEERS FOR SCIENCE

Fossils

Goal: To introduce students to the geological time scale, the fossil record, index fossils, and the uses of fossils.
Fits Tennessee standards 5.ESS1.7, 5LS4.1

I. Introduction – Fossils and Paleo environments
II.. Types of Fossils
III. Sedimentary Rock Layers/Columns
- **A.** Sedimentary Rocks
- **B.** Creating a Model of Sedimentary Rocks
- **C.** Explaining the Columns
- **D.** Dating with Index Fossils
- **E.** Usefulness of Fossils
- **F.** Looking at Real Fossils

Materials:
1 cylinder containing the larger string timeline
10 laminated timeline mats
10 jars containing fossils and sedimentary rocks
1 container with copralite, crinoid sample,
5 large versions of timeline table
32 observation sheets
10plates,
10 models of rock layers with fossils encased in boxes
10 jars of water
10 sets of jars containing sand and "fossils" (stones)
Jar 1: Pale yellow sand (limestone)with rocks representing containing trilobites and brachiopods
Jar 2: Brown sand (sandstone) with rocks representing brachiopods, shark's teeth, crinoids
Jar 3: White sand (limestone) with rocks representing ammonites, shark's teeth and brachiopods
Materials for VSVS demo
1 plate
1 column container
1 bottle of water
3 jars of sand and "fossils" (pebbles)

Why is the science in this lesson important?
An understanding of sedimentary layers is useful for understanding when and how life originated on Earth, as well as for studying evolution and historical changes in Earth's ecosystems

I. Introduction – Fossils and Paleo environments

A. <u>What are Fossils?</u>

- Pass out the model of rock layers with fossils encased in boxes, 1 per 3-4 students.
- Point out the fossils as they are referred to in this section.

- Q. What is the definition of the word "fossil"?
    - *It is a preserved piece of ancient life. It may look like the original life form, or it may be a piece of evidence that a creature lived. It takes millions of years to form.*
    - Stress that in most cases, a fossil is not the actual flesh and bone (or stem/leaf) of the organism. Fossilized organisms look like the original form, but the parts have been replaced with rocks or minerals that took the shape of the organism's remains.
- The oldest fossil found is dated at 2.2 billion years old – but we know that the earth is close to 4.6 billion years old, so we don't have fossils spanning earth's entire history.

B . Paleoenvironments

- Q. Ask students if they have ever found a fossil around home or anywhere in Nashville?
    - *If they say yes, ask them what type; ideally they will have found something that looks like a seashell.*
    - Rocks in Nashville have many fossils **of brachiopods** (clam-like animals), **crinoids,** and corals that are 400 million years old. Tell students to look at the brachiopods and crinoids in the rock layer model.
    - 400 million years ago, when these fossils were formed, what was the environment like? Hint – where do clams, crinoids, and corals live today?
        - *Underwater in shallow oceans.*
    - Fossils don't move from where an organism lived, so what does this say about Tennessee's location 400 million years ago?
        - *Underwater in a shallow ocean!*
- In Antarctica, dozens of fossil tree stumps have been discovered. Antarctica is covered mostly by ice today and no trees.
    - Q. What must be true about Antarctica's past climate?
        - *It was much warmer and supported large plant life like trees.*

II. Types of Fossils

There are 2 main types of fossils:

- **Trace fossils** include tracks, burrows, or dung from animals – any evidence that the animal lived that isn't an actual part of the animal's body. They form because an empty animal burrow or track can be preserved.
    - Examples are animal burrows, dinosaur poop, ripples in land, tracks,
    - Show students the trace fossil **copralite.**
    - Tell students that **copralite** is fossilized poop. It is millions of years old. Coprolites are the fossilized feces of animals that lived millions of years ago. They are trace fossils, meaning not of the animal's actual body. Scientists can look inside coprolites to see what they contain. If there are bone fragments, the animal was a carnivore. Tooth marks on the fragments, if present, can reveal how the animal ate its prey. Seeds, leaf remains, pollen or bark found in a coprolite suggest that the animal it came from ate plants.

- **Body fossils** are the mineralized hard remains of an organism or an imprint left from the remains. In these fossils, we should see actual features of the living organisms.
    - Q. Which parts of animals are preserved as fossils? Hint: many fossils are teeth, bones, or shells – how are these different from other parts of the body?
    - *Hard parts of animals' bodies have the ability to be preserved as fossils. Soft parts of their bodies are almost never preserved as fossil because they decompose too quickly.*

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- Show students the crinoid fossils

Question 1: What parts of an organism can turn into a fossil? *Hard parts like teeth, bones, or shells*

III. Sedimentary Rock Layers/Columns

Learning Goals:

- **Students understand how sedimentary rocks are formed.**
- **Students experiment with forming sedimentary layers and understand that fossils are deposited at the same time the as the sediment.**
- **Students understand that sediments are deposited in <u>horizontal</u> layers**
- **Students understand that older layers are at the bottom in a sedimentary layer, while younger layers are at the top**

A. Reviewing Sedimentary Rocks

- Q. Ask students what they know about sedimentary rocks. If these answers aren't given, go over them briefly:
    - Most sedimentary rocks are formed from sediments deposited in oceans, lakes or rivers.
    - Sediments form layers that pile on top of each other, which compress over time to create rock.
    - Types of sedimentary rock include sandstone (primarily from sands), limestone (primarily from shells), and shale. (primarily from mud).
    - Tell students to look at the sedimentary rocks in their jar.

- Q. Ask for a show of hands of which students have seen rock layers on the sides of the highway while driving around Nashville – this is sedimentary rock! Ask if anyone knows what type of rock this is.
    - *Limestone*
- Tell students that we are going to create a model of sedimentary rock layers.

B. Creating a Model of Sedimentary Layers

Materials for VSVS demo

1plate, 1 column container, 1 bottle of water

3 jars of sand and "fossils" (pebbles)

Materials for students, per group:

1 plate, 1 column containers (jars containing water), 1model of rock layers with fossils encased in boxes 1 set of numbered jars of sand, with different colors of sand representing different types of sedimentary rock and pebbles representing fossils

Jar 1: Pale yellow sand (limestone)with rocks representing trilobites and brachiopods

Jar 2: Brown sand (sandstone) with rocks representing brachiopod ,shark's teeth crinoids

Jar 3: Pale Yellow sand (limestone) with rocks representing ammonites, shark's teeth and brachiopods

32 observation sheets,

- Set up at the front of the class the apparatus to create the sedimentary rock column demonstration
- One VSVS member should draw a large diagram on the board to represent the column, based on the diagram on this page.
    - Do not draw the entire finished diagram. Start with the open-top rectangle representing the column (bolder lines). As each jar of sand is added, draw the layer line and write the color of the sand and "fossils" (rocks).

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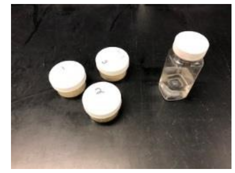
- Other VSVSers should pass out the columns (jars with water), jars of sand, and plates (1 per group of 2-3 students).
  Put the column on the plate to catch spills.



Tell students to look at the model of sand and fossils in a case.
  - The model represents fossils buried in layers of rock.
  - Tell them that the sand represents the type of sedimentary rock pale yellow is limestone and brown is sandstone).
  - The fossils in the model are real.

Tell students they are going to create sedimentary layers that are represented in the model.
- Demonstrate how to create the column and have the students do each layer after you do.
  1. Pour the container of water into the column, reminding students that sedimentary rocks form when sediments settle out of water and form layers.

  2. Explain to students that we are using different colors of sand to represent different types of sedimentary rock, and different color pebbles to represent fossils. **Point out that the fossils (pebbles) get deposited at the same time as the sand.**

  3. Pour all of the sand and "fossils" from container #1 into the column. Wait until each layer settles (~30 seconds) before pouring the next layer. Make sure students are adding the jars of sand to the column in the correct order (#1 first ...)
  4. When settled, pour all of container #2's contents into the column and wait for it to settle. Then container #3's contents. Make sure to update the drawing on the board as new layers are added.

C. Explaining the Column

- Q. Ask students to describe what happened when they poured each layer of sand.
  - *Sand settles through the water to make a flat layer at the bottom of the column.*
  - This is similar to sediment settling out of water to form layers; over millions of years the sediment is compressed and turns into rock.
  - Explain that sediment is deposited in horizontal layers, and it stays that way unless something disturbs it.
  - **Have students answer Question 2a on their observation sheet.**
    1. *Sediments settle and form rocks in* ***___horizontal_****layers.*

  - **Fossils are deposited at the same time the rock material is deposited. Therefore the ages of the fossil and rock in which it is found are the same.**
  - **Have students answer Question 2b on their observation sheet.**
    2. *What is the age of a fossil relative to the rock in which it is found?* ***The same_***

- Tell students to imagine that the process of creating their sand columns took millions of years to occur.
- Tell students that different rock layers represent different periods of time.
  - Q. Ask students which layer is the oldest in the column. Answer question 2c.
    - *The bottom layer; it was deposited first and other layers were deposited on top of it.*
  - Q. Ask students which layer is the youngest in the column. Answer question 2d.
    - *The top layer; it was deposited last, on top of all other layers.*

Your Notes:

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- How old are the middle layers? *(You can't tell for sure! But they are older than the top layer and younger than the bottom layer.)*
- Fossils succeed each other in a definite order – the oldest fossils in a series of layers will be in the lowest layer.

IV. Usefulness of Fossils

- Q. Why are fossils useful?
  - *Answers will vary, but they should focus on fossils telling us how earth has changed over time. Besides the answers below that we will go over, they might say something about figuring out what organisms ate in the past or where organisms migrated from.*

- Tell students that fossils are useful for:
  - Finding the age of rocks.
  - Learning what type of environment once existed in a region.
  - Showing evidence that species evolve over time.

B. Looking at Real Fossils – Timeline placemat

Materials - Fossils Placemat, jars of fossils

- Tell students to look at their observation sheet and point out the 4 eons.
- The **geologic time scale** covers earth's entire history.
  It is divided into **eons**, which are further divided into **eras.**
  - Eons and eras are not of equal length, but are based on events/organisms in certain time periods (eons) and when major extinctions happened (eras).

- Tell students we are going to focus on the last eon – the Phanerozoic Eon
- Briefly explain the layout of the timeline mat:
  - The top rectangle is the time scale of the Phanerozoic Eon in millions of years before present with 0 being present day (denoted by the stick figure at the end).
  - The different colors (pink, green and yellow) show the different **ERAS.**
  - The thick black lines represent mass extinctions from catastrophic events.
  - The other rectangles below the time scale correspond to the life spans of the organisms in the rectangles.
  - The pictures are the fossils of the organisms that the rectangle represents and images of what the organisms would have looked like.

- **ERAS** are characterized by unique advanced life forms and end with mass extinctions.
  - Q. What is meant by extinction? (*The last remaining members of a species have died out.)*
- Identify the **pink section** of the time scale as the **Paleozoic Era**. During this era:
  - Invertebrates such as trilobites, brachiopods, and crinoids, flourished in this era. Direct students to the images on the timeline to see what trilobites, crinoids & brachiopods look like.
    - Q. Does anyone know what makes an animal an invertebrate?
      The lack of a backbone.
      Animals are vertebrates (like us) if they have a backbone.
  - Early fish develop (direct attention to placemat for sharks).
  - Early land plants develop (direct attention to placemat for early ferns).
  - Early reptiles developed.

Your Notes:

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    - The biggest mass extinction occurred at the end of this era – 90% of all species became extinct. (Emphasize the magnitude of this extinction to students – tell them to imagine 90% of all animals on earth right now dying out.)

- Identify the **<u>green</u> section** of the time scale as the **Mesozoic Era**:
    - This is known as the Age of Reptiles, since many major reptile groups were dominant life forms.
    - Dinosaurs, birds, small mammals, flowering plants, and flies flourished.
    - Another mass extinction occurred at end of this era – 50% of all species became extinct, including dinosaurs.
    - Q. Does anyone know the current theory as to why the dinosaurs went extinct?
        - *Many scientists agree that it was likely due to the impact of a large meteorite near Mexico*.
- Identify the **<u>yellow</u> section** of the time scale as the **Cenozoic Era**:
    - Cenozoic means "recent life" – it continues up until today.
    - This is the Age of Mammals.
    - Some mammals are already extinct (woolly mammoth, saber-toothed cats), but another mass extinction hasn't occurred yet.

DO NOT PASS OUT THE JARS CONTAINING FOSSILS AND SEDIMENTARY ROCKS UNTIL YOU HAVE DONE THE FOLLOWING: Count the number of fossils. There must be 6 in each. These fossils are expensive and the jars must be returned with all 6 fossils.

Trilobite

- Tell the students that we will now look at real fossils of past organisms.
    - Hand out the jars of fossils (1 jar per group).
    - Tell students to identify each fossil and put it in the correct place on the timeline, using the pictures as a guide.
    - Some images are at the right for your reference
    - Walk around helping students as needed, and interact with the students to see what questions or thoughts they have about the fossils.

Brachiopod

- Tell students to look at your placemat and tell you the name of the oldest fossil
    - **Answer question3. What are the oldest fossils? *Trilobite***
- What fossils are now extinct?
    - **Answer question 4. *Trilobites and Ammonites***

Crinoid

IVC. Dating with Index Fossils

- Tell students that fossils can be used to determine the age of rock layers - these are called **index fossils**.
    - Not all fossils are index fossils.
    - Fossils are chosen to be index fossils if they:
        - Lived only a short time.
        - Are found in many areas worldwide.
        - Are easy to find (abundant).
        - Are easy to identify.

Your Notes:

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- Students should now look at the placemat AND their model of rock layers with fossils encased in boxes and predict which fossils are index fossils. Make sure they understand that MYA means "millions of years ago," and that the horizontal bars represent the length of time fossils of this type existed.

- Q. Ask students which fossils are index fossils and which are not. For the ones that are index fossils, what time period are they useful for dating the rocks from?
    - Brachiopods, Crinoids, Ferns and shark's teeth are not index fossils because they are in almost every time period.
    - Ammonites and trilobites are index fossils because they lived for just s short time and then became extinct. Trilobites can be used to date rocks 540 – 490 million years old. Ammonites can be used to date rocks 100 – 65 million years old.

Question 6: Which fossils on your timeline are used as index fossils? *Ammonites and trilobites*

- After students are finished putting the fossils in their correct locations, tell them to return all of their fossils to the box and to leave the lid off.
    - Go to each group and count the fossils (make sure they are all different and are actually the fossils).
    - If the set is complete, put the lid on the box and place it in the kit.
    - If any fossils are missing and students say they do not know where they are, tell the teacher immediately and have him or her help you find the missing fossils.

Leave the placement map on the student's desk.

DO NOT CONTINUE UNTIL ALL FOSSILS ARE ACCOUNTED FOR

V. Geologic Time – Optional (time permitting)

Materials:

1 cylinder containing the larger string timeline

A. Introduction

- Q. Does anybody know how old the earth is?
    - *4.6 billion years old. Write the number out in full on the board so they understand how much time this is (4600,000,000).*

- Q. Tell the students to think about how much of the earth's history humans have been around for, but tell them we will come back to this later. (*For about 1.5 million years*.)

B. Time Scale Model

- Point to the different eons and eras as you go through the timescale. This is on the students observation sheet. A large version is in the binder.
- Have students answer the questions as a class.
- Hold up the time scale model (the cylinder) with just a small piece of string pulled out so that all students can see it.

Tell students:

- The string represents the timeline of earth's history.
- The string covers the complete geologic time scale over a time of 4.6 billion years.

Your Notes:

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- The string is divided into the 4 eons, and the last eon is divided into eras.
- Note – the string is 19 feet long, so make sure you have enough room to "spread".
    a. One VSVS member or student volunteer will hold the string and another will hold the container and walk away while removing each eon and stopping when a knot is reached.
    b. A VSVS member will describe each eon to the students, while another writes names of eons and eras on the board as they are introduced.
    c. The string must be kept taught in a straight line so that the students get the concept of the length of time taken for each eon.

1. Pull the first (<u>camouflage-colored</u>) section of the string out, and stop as soon as you get to the first knot (between color changes).

- ***Tell students:***
    a. This first section represents the **Hadean Eon** lasting from 4.6-3.8 billion years ago (write time ranges of eons on board).
    b. **Major event**: No organisms living during this eon, but the earliest known rocks were formed.
    c. The oldest earth rock is dated at 4.03 billion years old and was found in the Canadian Rockies. The only rocks found that are older come from meteorites and the moon.1.
    d. Q. How do we know the rocks are this old? *Scientists use radiometric dating with radioactive isotopes (elements like uranium) in the rocks to figure out their age*.

2. Pull the second (<u>tan</u>) segment of the string until the second knot is reached.
    a. This represents the **Archean Eon** lasting from 3.8-2.5 billion years ago.
    b. **Major event**: During this eon, the first single-celled organism evolved.

3. Pull the third (<u>white</u>) segment of string until the third knot is reached.
    a. This represents the **Proterozoic Eon** lasting from 2.5 billion years ago - 540 million years ago.
    b. **Major event**: Multi-celled organisms evolved during this eon.
    c. The earliest multi-celled fossil is from Michigan and is dated at 2.2 billion years old.

4. Display the <u>black</u> end of the string.
    a. This last section represents the **Phanerozoic Eon** lasting from 540 million years ago - now.
    b. **Major event**: Life evolves from multi-celled organisms to plants, fish and animals as we know them today.
    c. Q. Have you been thinking about how long humans have existed?
    Humans only existed in the <u>very last knot</u> of the rope. (See the dangling skeleton!) This is an extremely short time in the history of the earth.

    This eon is subdivided into 3 smaller time intervals called **eras.** These eras are color coded with colored string twisted around the black cord.
    These are the eras studied with the Timeline Placemats.

Lesson written by: Pat Tellinghuisen, Coordinator of VSVS, Vanderbilt University
Courtney Luckabaugh, Lab Manager of VSVS, Vanderbilt University
We gratefully acknowledge the assistance of Dr. Molly Miller, Professor of Earth & Environmental Sciences, Vanderbilt University.
Reference:Chernicoff, S., & Whitney, D. (2007). *Geology: An Introduction to Physical Geology*. Upper Saddle River, New Jersey: Pearson.

Your Notes:

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Name ______________________________

Fossils Observation Sheet

1. What parts of an organism can turn into a fossil?

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2. Observe the sediments as you add them to the water. Are the following statements true or false?
   a. Sediments settle and form in horizontal layers True False
   b. Fossils are the same age as the rock it is found in True False
   c. The oldest layer is at the bottom True False
   d. The youngest layer is at the bottom True False
3. How old is the earth?
4. Look at your timeline placemat. What are the oldest fossils?
5. Look at your timeline placemat What fossils are now extinct?

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6. Which fossils on your timeline placemat can be used as index fossils?

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Eon:	**Hadean Eon**	**Archean Eon**	**Proterozoic Eon**	**Phanerozoic Eon**
Years:	4.6-3.8 billion years ago	3.8-2.5 billion years ago	2.5 billion years ago - 540 million years ago	540 million years ago - now
Major Events:	Oldest earth rocks form	Single-cell organisms evolve	Multi-cell organisms evolve	Advanced organisms like plants, mammals, and fish

Era:	**Paleozoic Era**	**Mesozoic Era**	**Cenozoic Era**
Dominant Organisms:	Invertebrates (trilobites, crinoids, ammonites, brachiopods)	Dinosaurs, birds	Mammals

<u>Fossils Observation Sheet - Answers</u>

1. What parts of an organism can turn into a fossil?

   Hard parts like teeth, bones, shell, skeletons

2. Observe the sediments as you add them to the water. Are the following statements true or false?

   a. Sediments settle and form in horizontal layers True

   b. Fossils are the same age as the rock it is found in True

   c. The oldest layer is at the bottom True

   d. The youngest layer is at the bottom False

3. Look at your placemat. What are the oldest fossils? *Trilobites*

4. Look at your placemat What fossils are now extinct? *Trilobites and Ammonites*.

5. Which fossils on your timeline can be used as index fossils?

   __ *Trilobites and Ammonites* How old is the earth?

Eon:	**Hadean Eon**	**Archean Eon**	**Proterozoic Eon**	**Phanerozoic Eon**
Years:	4.6-3.8 billion years ago	3.8-2.5 billion years ago	2.5 billion years ago - 540 million years ago	540 million years ago - now
Major Events:	Oldest earth rocks form	Single-cell organisms evolve	Multi-cell organisms evolve	Advanced organisms like plants, mammals, and fish

Era:	**Paleozoic Era**	**Mesozoic Era**	**Cenozoic Era**
Dominant Organisms:	Invertebrates (trilobites, crinoids, ammonites, brachiopods)	Dinosaurs, birds	Mammals

VANDERBILT STUDENT VOLUNTEERS FOR SCIENCE
http://studentorg.vanderbilt.edu/vsvs

Inheritance and Blood Typing

GOAL To introduce the students to the study of genetics through an activity dealing with blood typing
Fits TN standards: 7.LS3.3

VSVSer LESSON OUTLINE

_______ **I. Introduction**
Give a brief introduction to the volume and the components of blood in the body.

_______ **II. Red blood cell demonstration**
Show the models of red blood cell and explain what an antigen is and how it relates to blood type.

_______ **III. The Kidney Problem**
Students will perform an experiment to determine the blood types of family members to see if they qualify as kidney donors for their mother/wife.

_______ **IV. Analysis**
Using the data obtained from part III, the students will analyze their results.

_______ **V. Optional: Blood genetics and Punnett squares**
Explain how blood type is determined genetically and show how Punnett squares can be used to determine genotype. Provide definitions for genotype, phenotype, dominant, and recessive.

LOOK AT THE VIDEO BEFORE YOU GO OUT TO YOUR CLASSROOM
https://studentorg.vanderbilt.edu/vsvs/lessons/
USE THE PPT AND VIDEO TO VISUALIZE THE MATERIALS USED IN EACH SECTION.
Students will work in pairs for the activity.

1. Before the lesson:
In the car ride, read through this quiz together as a team. Make sure each team member has read the lesson and has a fundamental understanding of the material.
1. Explain the differences in the antigens and antibodies among the blood types.
2. a. Which blood types can Type A donate to and receive transfusions from? Why?
b. Type B? c. Type AB? d. Type O?
3. Why is blood typing so important? What would happen if someone received a transfusion of an incompatible blood type?
4. Finish this Punnett square to determine the possible blood types of the children from parents with AO and BO types:

	A	O
B		
O		

2. During the Lesson:
Here are some Fun Facts for the lesson – for VSVSers

- Usually a person has one blood type for their whole life, but infection, malignancy (like cancer), or autoimmune diseases can cause a change. A bone marrow transplant may also do this; the patient will eventually convert to the donor's blood type.
- Blood typing is important during pregnancies; if the father has an incompatible blood type to the mother, care must be taken so that the mother doesn't develop antibodies against the baby's blood that attack the baby's RBCs (hemolytic disease of the newborn (HDN) - has to do with Rh + and -, but not covered in lesson). Mothers often receive shots (Rho(D) immune globulin) to prevent this from happening.
- Blood typing also used to be heavily used for paternity tests and in criminal investigation. Actual blood isn't always necessary; about 80% of the population secretes the antigens/proteins/antibodies/enzymes characteristic of their blood type in other bodily fluids and tissues. A serologist could, for example, be able to tell if the source of a sample of blood came from the victim or the criminal. DNA testing, though, is used for detailed analysis.
- Type O is generally considered the "universal donor" type because it does not contain A or B antigens that would be rejected by A, B, or AB blood types. (However, there are other antigens that come into play, so in real life situations, hospitals categorize blood type on a more detailed level.)
- Even though Type O is recessive, it is the most common blood type because it is the ancestral form; the A and B antigens are mutations.
- Infants get antibodies passively from their mothers but start making them independently when they are three months old.
- Clinical trials are being done on a bacterial enzyme that can convert RBCs of A, B, and AB types into O by stripping away their antigens. This could have profound implications for blood transfusions.

UNPACKING THE KIT – what you will need for each part

FOR PART I. INTRODUCTION:

1 1 liter bottle (containing liquid with red dye)

FOR PART II RED BLOOD CELL DEMONSTRATION:

Set of blood cell models (Wards Blood Typing Demonstration Model, 14W8327)
Each set for VSVS demonstration contains

- 1 plastic bag containing 2 plastic blood cells each with a blue "A" peg (the A antigen) attached and 1 yellow Y –shaped pieces (the "B" antibodies)
- 1 plastic bag containing 2 plastic blood cells each with a yellow "B" peg (the B antigen) attached and 1 blue Y -shaped pieces (the "A" antibodies)
- 1 plastic bag containing 2 plastic blood cells each with both a blue "A" peg (the A antigen) AND a yellow "B" peg (the B antigens) attached. (No antibodies included)
- 1 plastic bag containing 2 plastic blood cells with no antigens attached and 1 blue Y -shaped piece (the "A" antibody) and 1 yellow Y –shaped piece (the "B" antibody)

15 Blood Types handouts.

FOR PART III. THE KIDNEY PROBLEM:

15 24-well plates, 15 plates, 15 blood testing worksheets, 30 safety goggles
15 ziploc bags with
1 dropping bottle containing fake blood labeled "Mrs. Sanderson"
1 dropping bottle containing fake blood labeled "Mr. Sanderson"
1 dropping bottle containing fake blood labeled "Jill"
1 dropping bottle containing fake blood labeled "Jack"
1 dropping bottle containing "Anti-A serum"
1 dropping bottle containing "Anti-B serum

Your Notes:

I. INTRODUCTION

Learning Goals:

- Students describe the composition of blood, including how antigens and antibodies determine blood type in different individuals.
- Students understand the relationship between antigens and antibodies, and identify which blood types are compatible as donors and receivers

Write the following vocabulary words on the board:
Antibodies, antigen, Punnett square, blood cell, ABO blood type
Ask students: How much blood do you think is in the human body? *About 5 liters of blood*.

At this point, **show the students the 1-liter bottle** and tell them that their bodies contain about 5 liters of blood.

Ask students: What is in blood? (What makes up blood*?)*

<u>Briefly Explain:</u>:
Blood is composed of a liquid (plasma) and solids (red and white blood cells and platelets).
Plasma—yellow-colored liquid that is primarily (92%) water; makes up most of blood volume (55%). It carries metabolites, nutrients, hormones, wastes, salts and proteins throughout the body and contains the anti-A and anti-B antibodies
Red blood cells (RBCs)—shaped like a donut, but without a hole; carry oxygen; give blood the red color; make up 40-45% of blood.
White blood cells (WBCs)—cells that are a part of the immune system. There are several types of white blood cells; one can produce **antibodies** which can help destroy bacteria and viruses.
Platelets—cell fragments that are responsible for clotting and scab formation

Tell the students that this activity will focus on characteristics of red blood cells.

Ask students: What are the different blood types? *There are four blood types: A, B, AB, and O*.
Blood typing is one way of characterizing what kind of blood someone has. It is determined by the type of **<u>antigen</u>** that is present on the surface of the red blood cells.

II. RED BLOOD CELL DEMONSTRATION

MATERIALS

Set of blood cell models (Wards Blood Typing Demonstration Model, 14W8327)
Each set for VSVS demonstration contains

- 1 plastic bag containing 2 plastic blood cells each with a blue “A” peg (the A antigen) attached and 1 yellow Y –shaped pieces (the “B” antibodies)
- 1 plastic bag containing 2 plastic blood cells each with a yellow “B” peg (the B antigen) attached and 1 blue Y -shaped pieces (the “A” antibodies)
- 1 plastic bag containing 2 plastic blood cells each with both a blue “A” peg (the A antigen) AND a yellow “B” peg (the B antigens) attached. (No antibodies included)
- 1 plastic bag containing 2 plastic blood cells with no antigens attached and 1 blue Y -shaped piece (the “A” antibody) and 1 yellow Y –shaped piece (the “B” antibody)

15 Blood Types handouts.

1. The red blood cell has proteins on its surface that determines what blood type a person is. These proteins are called **antigens.** An antigen is a chemical tag that the body can identify with antibodies. An antigen is any substance to which the immune system can respond.

Your Notes:

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2. Blood cells are named by the type of antigen on its surface.

3. Show students the bags of blood cells. Tell students that the red donut shape is a model for a red blood cell. The pegs are the **antigens** (blue is the "A" antigen, yellow is the "B" antigen). The Y-shapes are the **antibodies.**

4. Show students the bag containing blood cells that have the blue pegs attached – this red blood cell now has an **"A" antigen**. It is a **Type A blood cell.** It also contains a yellow Y-shaped anti-B antibody present in the plasma.

5. Show students the bag containing blood cells that have the yellow pegs attached. This red blood cell has a **"B" antigen –** it is **a Type B blood cell.** It also contains a blue Y-shaped anti-A antibody present in the plasma.

6. Show students the bag containing blood cells that have the blue AND yellow pegs attached. Ask the students what type of blood cell this is. ***Answer: an AB blood cell.*** There are no antibodies in the plasma.

7. Show the students the bag containing the fourth blood cell that does not have any antigens on its surface. Ask the students what type of blood cell this is. ***Answer: an O blood cell*** (if the students are confused, tell them to think of the cell has having zero (O) antigens on its surface)
There are both A and B antibodies present in the plasma and in the plastic bag.

8. Tell students to look at Table 1 on the handout to see a comparison of the different types of blood cells side-by-side, and the relative representation of blood types in the American population.

9. The A-B-O blood typing system classifies blood by the **antigens** on the red blood cell surface and the **antibodies** in the plasma.

   a) **Antibodies** help in removing unwanted things from the blood. If the immune system encounters an antigen that is not found on the body's own cells, it will launch an attack against that antigen. Many antibodies recognize antigens by being able to match the shape and remove them by binding to the antigens – seen as clumping in the experiment.

   b) If a person has blood cells with **the A antigen**, that person will have antibodies against the B antigen in the plasma. It does not normally have antibodies against cells with the A antigen. If it had A antibodies, it would be like having a double agent on your team – the A antibodies would attack the healthy cells in your body. This is the basis of autoimmune disorders where the body's immune system incorrectly attacks healthy cells.

   c) If someone has blood cells with the **B antigen**, that person has antibodies against cells with the **A antigen** in its plasma.

   d) People with AB blood cells do not have antibodies to either type of antigen, while people with O blood cells have antibodies to both.

Your Notes:

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Tell students to look at the Table 1in the handout.

Table 1

ABO Blood Type	Contains Antigens A	Plasma Contains Antibodies	Agglutination (clumping) occurs with
A	A	Anti- B	Anti-A serum only
B	B	Anti-A	Anti-B serum only
AB	A and B	None	Both Anti-A serum and Anti-B serum
O	None	Anti-A and Anti-B	Neither

Blood Transfusions and Organ Transplantations
When transfusions of blood were first attempted, some were successful but others often fatal. For a blood transfusion to be successful, the recipient's blood must not contain antibodies that will react with/attack the antigens in the donor's blood.

Important: donor's blood contains ONLY red blood cells. There is no plasma in the donor's blood. Therefore, there are no antibodies in the donor's blood.

If a person has blood type A, he cannot receive Type B or Type AB blood because the Anti-B antibodies in the recipient's blood will bind to the B antigen in the donor's blood and destroy these cells.

10. Ask students if they can determine what types of blood a person with Type B blood **can receive? *O and B.***
11. Ask students if they can determine what types of blood a person with Type AB blood **can** receive? ***A, B, AB, O. This person is called a universal recipient.***
12. Ask students if they can determine what types of blood a person with Type O blood **can receive? *Only O.*** But this person can give blood to anyone and is called a universal donor.

These results are summarized in the Table 1 on the handout.

This **reactivity** demonstrates why people have their blood tested prior to a transfusion or transplantation. If blood types are not compatible, any transferring of blood can have negative consequences.

III. THE KIDNEY PROBLEM

Learning Goals:
- Students understand the relationship between antigens and antibodies, and identify which blood types are compatible as donors and receivers
- With support, students identify a method for determining blood type

Your Notes:

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MATERIALS
15 24-well plates
15 ziploc bags with
  1 dropping bottle containing fake blood labeled "Mrs. Sanderson"
  1 dropping bottle containing fake blood labeled "Mr. Sanderson"
  1 dropping bottle containing fake blood labeled "Jill"
  1 dropping bottle containing fake blood labeled "Jack"
  1 dropping bottle containing "Anti-A serum"
  1 dropping bottle containing "Anti-B serum"
15 plates
15 blood testing worksheets
30 safety goggles

Tell students that they will work to determine the blood type of the members of a "family" so that a donor match can be found.

Scenario: Mrs. Sanderson developed a rare kidney disease that causes the kidney to lose function over time. She had been doing well for the past few years, but it seems that her kidney is starting to decline rapidly. Her doctors suggest that the best way for her to live a long life is for her to receive a kidney transplant. Her family has just been informed of her health situation and they are asked to undergo a blood test. If a family member shares her blood type and is willing to donate a kidney to her, Mrs. Sanderson will probably be able to get better.

(OPTIONAL INFO) The major function of the kidney is to filter the blood to get rid of various wastes such as urea. People only need one kidney in order to live normally.

Blood Typing
Tell the students that they will be blood test specialists.
Remind the students that the blood samples are not really blood.
In order to donate a kidney (or blood), there must be a match of blood types between the donor and the recipient to prevent the recipient's antibodies from attacking the donor cells.
There is a simple test to determine blood type of the recipient and possible donor.
  Antisera are made containing either A antibodies or B antibodies. Serum is a "purified" form of plasma that contains the antibodies.
  When the antiserum is added to each blood sample, it can react with the blood sample and cause the red blood cells to clump together – this is called **agglutination.** This would eventually result in clogged blood vessels and cause kidney failure.

Show students the two red blood cell models that are labelled Type "A". Connect the two blue antigens on the cells with the blue anti-A serum Y- shape. This represents the reaction of clumping or agglutination.
Similarly, show the students the two red blood cell models that are labelled Type "B". Connect the two yellow antigens on the cells with the yellow anti-B serum Y- shape.
These results are summarized on the handout in Table 1 and the "Clumping" picture.
a. If the blood clumps in the anti-A serum and not the anti-B serum, then the blood type is A.
b. If it clumps for the anti-B and not for the anti-A, then the blood type is B.
c. If it clumps for both, the blood type is AB.
d. If there is no clumping, then the blood type is O.

Your Notes:

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Divide the students into pairs. Pass out safety goggles and one set of materials to each pair of students.

Tell the students:

1. Put on the goggles and wear them until after they finish using the dropper bottles.
2. Look at the 24-well plate and find the column labels 1-6 (across the top) and the row labels (A-D) (along the side). You will be using columns 1-4 and rows A and B.
3. Add a squirt of Mrs. Sanderson's samples to 1A and 1B (the first two wells in Column 1). Replace the cap on the bottle labelled Mrs. Sanderson.
   Add a squirt of anti-A (blue) to the first well in row A(1A). Observe whether a precipitate (or cloudiness) occurs. If a precipitate or cloudiness occurs, enter a "+" in square A-1 in the table below. If nothing happens, enter a "–".
   Add a squirt of anti-B (yellow) to 1B, recording a "+" or a "– " in the appropriate square of the table.
4. Repeat for Mr. Sanderson's samples in 2A and 2B (the first two wells under Column 2) and enter your results. Replace the cap on the bottle labelled Mr. Sanderson.
5. Repeat for Jill's samples to 3A and 3B (the first two wells under Column 3). Record the results. Replace the cap on the bottle labelled Jill.
6. Repeat for Jack's samples to 4A and 4B (the first two wells under column 4). Replace the cap on the bottle labelled Jack. Replace the caps on the bottles labelled anti -A and anti-B.
7. Determine the blood type:
   -- **Type A** will clump only in anti-A serum
   -- **Type B** will clump only in anti-B serum
   -- **Type AB** will clump in both anti-A and anti-B serum
   -- **Type O** does not clump when either serum is added.

IV. ANALYSIS

Learning Goals: Students understand the relationship between antigens and antibodies, and identify which blood types are compatible as donors and receivers

1. From the data that was obtained, tell the students to figure out what the blood type of each family member is. The instructions on how to determine the blood type of each individual are written in the last step of the handout. Write these answers on the board and/or share with the class.
2. From the data tables, ask the students if any of Mrs. Sanderson's family will be able to donate their kidney to her.

Because Mrs. Sanderson's blood clumps in the anti-A serum, she is blood type A. In the same way, Mr. Sanderson has type B blood and Jill has type AB blood and they will not be able to donate. However, Jack, with type O blood, can and does donate a kidney, saving his mother's life.

V. BLOOD GENETICS AND PUNNETT SQUARES

Learning Goals: Students use Punnett squares and basic genetics to construct an explanation for why people have certain blood types

Your Notes:

We can tell what blood type someone has by analyzing their red blood cells for their antigens.

Ask the students: *Can we tell what possible blood types an offspring will have just by knowing what his or her parents' blood types are?* Accept answers. Yes, by using a Punnett square.

Ask the students: *What do you think determines which antigens end up on the red blood cells?*
Tell students that antigens and thus, blood type, are determined by the genes (on chromosome 9!) that get passed on from parents (in the same way that other traits are passed down from parents).

An individual's ABO type is determined by the inheritance of 1 of 3 alleles (A, B, or O) from each parent.
Explain that each parent has two blood type alleles. This is what's known as a **genotype**.
Each parent will pass on one of these alleles (remember that they have two!) to their child.
These alleles are for the A antigen (blood type A), the B antigen (blood type B) or no antigens (blood type O). The combination of two of these alleles will determine what the blood type will be.

Ask students to determine the possible genotypes of offspring? If they do not know how to use Punnett squares, briefly explain by drawing the square on the board:

1. Draw a Punnett square (Figure 1.) and compare it to a four-square court. The mother's genes are on top and the father's genes are on the left side.
2. The empty boxes are filled by writing the each of the mother's genes in the boxes directly below it and each of the father's genes in the boxes directly to the right of it (figure 2). In this example, the mother has an AA blood genotype, while the father has an AB blood genotype.

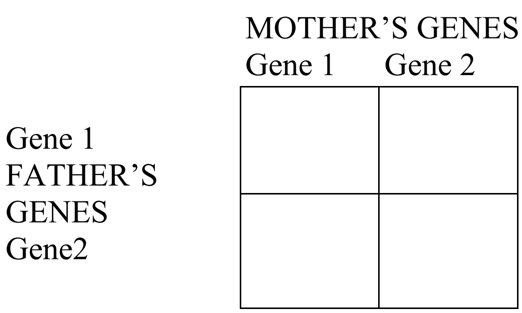

Figure 1. Punnett Square

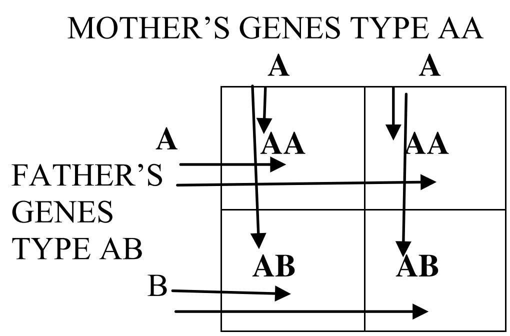

Figure 2. Filling in the Punnett Square

3. After filling in the empty boxes by bringing down both A genes contributed by the mother and bringing over the A and B genes contributed by the father, we find that their offspring will either have an AA genotype or an AB genotype.

4. Review the terms **dominant** and **recessive** with the students.
   In the case of blood, the A and B genes are **co-dominant**. This means that if a child inherits both an A gene and a B gene, both A and B antigens will be found on the surface of an RBC and the phenotype will be AB.
   Individuals who have an AO genotype will have an A phenotype.
   People who are type O have OO genotypes. In other words, they inherited a recessive O allele from both parents.

Your Notes:

5. Tell students to fill out the last line in the observation sheet, assigning possible genotypes to the family members.

6. Tell students to look at the Punnett square on the Handout.

The possible ABO alleles for one parent are in the top row and the alleles of the other are in the left column. Offspring genotypes are shown in black. Phenotypes are red in the brackets.

Parent Alleles	A	B	O
A	AA (A)	AB (AB)	AO (A)
B	AB (AB)	BB (B)	BO (B)
O	AO (A)	BO (B)	OO (O)

http://anthro.palomar.edu/blood/ABO_system.htAsk students:

If Jack has type O blood, what are the genotypes for his mother and father. Have the students fill out their Punnett square using all the possible genotypes for Mr. and Mrs. Sanderson.
For VSVS Information: make sure you know the logic used in determining the possible genotypes.
Since Jack is type OO, he must have the genotype OO. He has to get one O from his mother and one O from his father. So Mrs. Sanderson must have AO and Mr. Sanderson must have BO

Answer sheet
Blood Typing Lab Data Sheet

	Column 1	Column 2	Column 3	Column 4
	Mrs. Sanderson	**Mr. Sanderson**	**Jill**	**Jack**
Row A Anti-A serum	**+ Yes**	**- No**	**+ Yes**	**- No**
Row B Anti-B serum	**- No**	**+ Yes**	**+ Yes**	**- No**
Blood Type (A, B, or O)	**A**	**B**	**AB**	**O**
Possible Genotype	**AA or AO**	**BB or BO**	**AB**	**OO**

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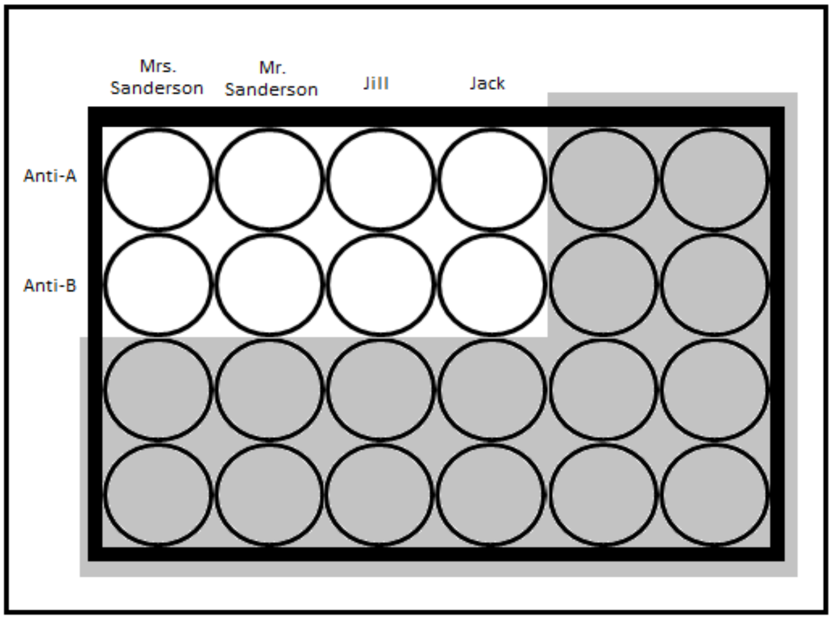
Blood Typing Lab Data Sheet NAME ___________________________



	Column 1	Column 2	Column 3	Column 4
	Mrs. Sanderson	**Mr. Sanderson**	**Jill**	**Jack**
Row A Anti-A serum clumping occurs = + nothing happens = -				
Row B Anti-B serum clumping occurs = + nothing happens = -				
Blood Type (Phenotype) (A, B, AB or O)				
Possible Genotype (AA, AB, BB, AO, BO, OO)				

Mrs Sanderson

Mr Sanderson

Mrs Sanderson

Mr Sanderson
